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Design of Clinical Decision Support System (CDSS) based on Integrated Childhood Illness Management (ICIM) at Primary Health Care Centre

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Abstract. The neonatal period is an important period in life. Infant Mortality Rate (IMR) is the number of infant deaths in the first 28 days of life (neonatal) per 1000 live births (PERMENKES No 53, 2014). IMR in Indonesia is still high compared to other ASEAN countries, based on data in 2016 showed that IMR reached 25.5, its mean that there were around 25.5 deaths per 1,000 babies born (BPS, 2016). Poor neonatal management clinically would cause abnormalities, and could even lead to lifelong disability, and death, while administratively could cause legal problems. Neonatal management required complete clinical data support, relevance, accurate and timeliness aspects. This research was a mixed method research with action research approach and prototype method in the development of Clinical Decision Support System (CDSS). This study produced CDSS based on Integrated Childhood Illness Management (IMCI) algorithm for neonatal service management in primary health care center. The results of testing system that used black-box technique was accordance with the requirements and obtained a valid overall result. DSS IMCI could be integrated with Electronic Health Record (EHR) so appropriate clinical decision making could be done.
Keywords— **CDSS, IMCI, Neonatal Management.**

1. Introduction

The research showed that more than 50% of infant deaths occur in the neonatal period in the first month of life. Neonatal is infants aged zero to 28 days. [1,2] Research results from the Central Statistics Agency (BPS) showed that infant mortality rates had declined since 2012 to 2016, but data in 2016 showed that IMR was still high at 25.5, meaning there were around 25.5 deaths per 1,000 babies born. [3] Poor handling of newborn will cause abnormality and even could lead to lifelong disability and death. Preventive was the best action that must be done in neonatal care because the neonatal period was the most critical period in the baby's growth and development phase. Diagnosis played an important role in medical care, it took the right decision to make a diagnosis and action. This need to be well known by health workers, especially midwives, who always provide health services for mothers and babies. The highest cause of neonatal mortality based on WHO statistical data was prematurity, complication at childbirth process (neonatal asphyxia), and sepsis [4]. Newborn babies need immediate, fast, appropriate, and safe care. The childbirth process was generally focused on the mother, but the management of childbirth was said to be successful if the mother and baby were in optimal health. Primary health facilities were the first level health care facilities that act as gate for advanced health services. The incidence of infant kidnapping and trafficking which included the criteria of trafficking in person must also be of particular concern and increase the urgency of the need for completeness of data on newborn service [5]. The application of information technology was needed as a solution to support the completeness of data and clinical decision support in childbirth service [6] The Indonesian Ministry of Health issued technical guidelines for basic health service for neonatal in the form of Integrated Management of Childhood Illness (IMCI). IMCI was intended to reduce infant and under-five mortality rate, done by health workers in primary and secondary health care centers that provide neonatal health

service [7]. IMCI implementation required systematic classification and special management, where health workers must be able to master the classification algorithm at the primary health care level. Constraint that often encountered in the field was that many of the health workers had limited knowledge related to the IMCI algorithm. The application of information technology in the form of a Clinical Decision Support System (CDSS) was expected to improve the efficiency and safety of health services. The use of CDSS based on MTBS algorithm in primary health care facilities was expected to be able to play a role as a tool in classifying and managing cases in neonatal service. CDSS could be combined with an Electronic Health Record (EHR) so that integration would occur for clinical decision making. This had an impact on the realization of improving the quality of health service.

2. Literature Review

Integrated Management of Childhood Illness (IMCI) was a management through an integrated approach in the management of sick toddlers who come in health service, both regarding several classification of disease, nutritional status, immunization status and handling of sick toddlers and counseling provided. The IMCI material consists of assessment step, classification of diseases, identification of action, treatment, counseling, home care and when to return for follow-up. The target of IMCI was children aged 0-5 years and divided into two target groups, namely the age group 1 day to 2 months and the age group 2 months to 5 years. IMCI activities were effort aimed at reducing morbidity and mortality while improving the quality of health service in primary health care [8]

Decision Support System (DSS) can be interpreted as an application from data processing and produces a decision analysis that can be used for decision making process. One of the popular and very helpful used of DSS was in the field of health or commonly referred to as the Clinical Decision Support System (CDSS). CDSS build health prediction application [9][10]. CDSS had a large potential in improving health quality and better health care effectiveness. CDSS was a clinical decision support system that usually designed to integrate basic medical knowledge, patient data and inference machine to produce advice from specific diseases. There were three categories of CDSS benefits in practice:

a. Improving patient safety: reduce medical errors, improve treatment accuracy and order medication;
b. Improving service quality, shorten treatment time, increase clinical pathways and guidelines, used of up-to-date evidence base, improve clinical documentation and patient satisfaction;
c. Increasing efficiency, namely reducing cost because the processing sequence was faster, avoiding repeated checks, providing cheap good quality generic drugs [11] [12].

Prototyping model was a software development process that begin with the collection of requirement from the system, followed by the creation of prototype and evaluation from users. Stages of the Prototyping Model [13] [14]:

a. Collection of Need: customers and developers together defined the format of the entire software, identify all the need, and the outline of the system to be created.
b. Build Prototyping: build prototyping by making temporary design that focus on serving customers (for example by making input and output format).
c. Using this Evaluation System was carried out by customers whether the prototyping that had been built was in accordance with the customer's wishes.
d. System Encoding: In this stage the prototyping that had been agreed was translated into the appropriate programming language.
e. Testing the System After the system had became a software that was ready to use, it must be tested before use. This test was done with White Box, Black Box, Base Path, architectural testing and others.
f. System Evaluation: Customer evaluated whether the finished system was as good as the expectation.
g. Using the system: Software that had been tested and accepted by customers was ready to use.

Action research was one form of research design, in action research the researcher describe, interpret and explain a social situation at the same time as making change or intervention with the aim of

improvement or participation. The simplest form of action research stage, there are at least 4 stages in the research. These four stages are diagnosing action, planning action, taking action and evaluating. [15] [16]

3. Method

3.1Research design

This research used action research method and prototype model in the system design that was built. Action research was a form of research design, in which researcher could describe, interpret and explain a social situation at the same time as making changes or interventions with the aim of improvement or participation. The research stage based on the action research method were as follow [15] [16]:

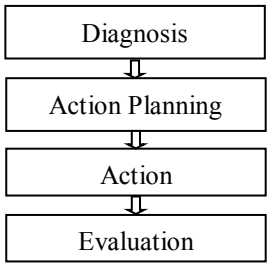

Figure 1. Research Stage

The research stages included:

1. Diagnosis Stage
   Identified the main problems that were related to neonatal service management in health care facility in order to be the basis for application design. At this stage researchers identified the need of health workers both doctor and midwife in health care facility in implementing neonatal management, carried out by conducting in-depth interviews and observation.
2. Action Planning Stage
   Researcher and respondent (doctor and midwife) jointly understand the existing problem related to the implementation of neonatal health service, then proceed with preparing appropriate action plan to resolve existing problems based on the IMCI algorithm. At this stage the application design start entered the system design stage by using a prototype design model. The researcher together with the respondent made an initial sketch of the planning of the CDSS algorithm and determined the content to be displayed in the application.
3. Action Stage
   In this stage the researcher implement an action plan to design the CDSS interface, database, inference engine according to system requirements.
4. Evaluation Stage
   The CDSS prototype trial of neonatal service was carried out at health care facilities that serve neonatal management. This stage was intended to determine the possible difficulty of using CDSS applications in neonatal management service based on the IMCI algorithm.

3.2 Analysis Unit

The unit of analysis in this study was all doctor and midwife who were tasked with implementing neonatal care management in primary care facility in this case especially clinician at the Sakinah Kaliurang clinic and its networking midwife. There were 2 doctors and 4 midwives.

3.3 System Design Model

The model that would be used for the design of the CDSS system in this study was the prototyping model, a fast design model and testing of a working model (prototype) of a new application through an interaction process and repeatedly used by information systems experts and business experts [17]. With

this prototyping method developer and user can interact with each other during the system creation process [14]. The prototype model in this study consists of the following steps:

1. Collection of Need

Researcher and respondent (user) together defined the format and overall need of the software. In this study interview and observation were conducted to identify all need, and the outline of the system to be created.

2. Build prototyping

Build prototyping by making a temporary design that center on the presentation to the user (for example by making input and example of output) based on the IMCI algorithm. At this stage researcher made system design and software by paying attention to known need from the previous stage. This stage included flowchart making, Data Flow Diagrams (DFD), Entity Relationship Diagrams (ERD) and database creation.

3. Protoptyping Evaluation

This evaluation was carried out by respondent whether the prototyping that had been built was in accordance with the wishes of respondents as user. If it was appropriate then the fourth step will be taken. If not, then prototyping was fixed by repeating steps 1, 2, and 3.

4. Encoding System

This phase of prototyping had been agreed upon coding by translating it into programming languages.

5. Testing System

At this stage the test was carried out in term of logic and program functionality to examine and minimize errors.

6. Evaluation System

The user evaluated whether the finished system was as good as the expectation. If so, then the seventh step would be done, if not then repeat step 4 and

7. Using the system

Neonatal management CDSS software that had been tested and accepted by the user was ready to use

3.4 Data Collection and Analysis Method

The used data collection method in this study were interview, observation and discussion. The used data analysis method in this action research was descriptive qualitative, which was carried out by qualitative data analysis and presented descriptively. Validity test to determine data validity by using time, source and triangulation method.

4. Result

4.1Diagnosis Stage

The diagnosis stage was done by entering the initial stage of the prototype model, namely identification of need. This stage identified the construction of the CDSS neonatal management at FKTP. Took an instruction through observation, interview and discussions with clinicians implementing neonatal clinical service in FKTP in this case, especially clinicians at the Sakinah Kaliurang clinic and its network midwives. There were 6 respondents in this study, namely 2 one-roof midwives and 2 network midwives and 2 doctors. The result of the identification of need were obtained by respondents need related to support when implementing clinical service for newborn babies in the form of universal precaution during initial assessment before the baby was born and immediately after the newborn baby. Support needed in the form of organized action flow as the implementation of IMCI (Integrated Management of Childhood Illness) and the need for uniformity of form related to the instrument of catching data completeness and related legality of documentation carried out including the issuance of birth certificate.

Then the researcher combined the results of the interview conclusion and discussion with reference that related to the applicable regulations from the Ministry of Health, namely the Republic of Indonesia Health Minister's Regulation Number 53 of 2014 concerning Essential Neonatal Health Service article 4 paragraph 2 about essential neonatal service up to 6 (six) hours.

4.2 Action Planning Stage

Researchers and respondents (doctors and midwives) jointly understand the existing problem related to the implementation of neonatal care management, then proceed with preparing appropriate action plan to solve existing problem based on the IMCI algorithm. At this stage the application design began to enter the system design stage by entering the second and third prototype model stage, namely developing prototypes and prototype evaluation. Prototype development was carried out with data requirement related to the clinical service of newborn that had been obtained in the previous stage (need identification stage), then made the mechanism of pressure to detect need service. This stage generated Data Flow Diagrams (DFD) as follow:

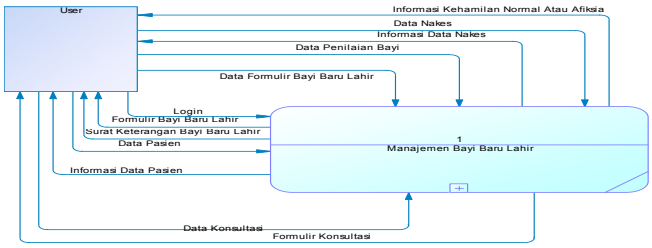

Figure 2. DFD Level 0 CDSS prototype neonatal management at FKTP

Flowchart diagram was a graph technique used to explain information flow and data transformation from input to output.[5] DFD level 0 or also commonly called context diagram was a description of how the system interact with external entity, in this case the user consisted of midwives implemented activity related to clinical service of newborn babies at FKTP. Level 1 DFD described more detail of level 0 DFD related to input-process and output in the support system for completing clinical service data for newborn babies. DFD in Indonesian was referred to as DAD (Data Flow Data) showed an overview of input-process-output from a system/software, then transformed by elements of processing and data objects flowing into the software, then transformed by elements processing, and data objects the result would flow out of the system or software [5]

Figure 3 showed the design of the Prototype Entity Relation Diagram (ERD) Supporting the Completeness of Clinical Service Data for Newborn Babies in FKTP. ERD was a network model that described the composition of data stored from the system in an abstract. The following ERD picture described the relationship between data in the database that had a relationship between relation, namely between entities nakes (health worker) in this case the midwife or doctor responsible for implementing service with patient entitiy, service and infant forms.

Figure 3. ERD Prototype CDSS neonatal management at FKTP

The third stage of the prototype model was prototype evaluation. The result of prototype development in the form of DFD and ERD would be implemented and evaluated whether they can be accepted by the user. User in this study were respondent who will use operational result application from the developed

prototype. Evaluation was carried out through re-discussion activities with respondents, namely the neonatal service delivery midwife at FKTP. The user evaluated whether the system was ready as expected. If so, then the next step was the implementation stage of the action in the form of coding system, but if not then repeat step 1 and 2.

4.3Action Stage

In this stage the researcher implemented an action plan to design the CDSS interface, database, inference engine according to system requirement. The prototype model went to stages four and five. The fourth stage was coding the system, and the fifth step was testing the system. The stage encode the system in the form of a prototyping that had been agreed upon coding by translating it into a programming language. Then entered the stage of testing the system by testing in term of logic and program functionality to examine and minimize error. The result of the system test used the black-box technique were obtained valid conclusion on the overall functionality tested.

4.4Evaluation Stage

This stage was the final stage of the action research method, and entered the sixth and seventh stages of the prototype model. The sixth and seventh stages were the final stage which consist of evaluating the system and using the system. The user evaluated whether the finished CDSS was as good as the expectation. Evaluation was done by using the application display by the user. The initial display started with the main menu for login page.

Figure 4. Main Menu For Login

The program started with the login form entering the username and password then by clicking the login button. If the username and password were correct then it went to the home page and if wrong, it will return to the login page. The login view contained a menu to determine whether to use doctor or midwife access rights.

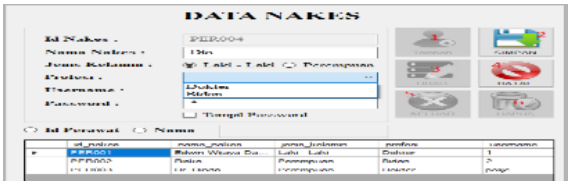

Figure 5. Display of Health Data

The Data Nakes (Health Worker) menu in Figure 5 served to add / register new data nakes, and can also be used to view registered health data. This was in accordance with the results of identification of need to the user through interview and discussion.

Figure 6. Display of Patient Data

The Patient Data display menu function to add or register new patient data, and can also be used to view data of patient who had registered. The patient data menu consisted of inputting the patient's social data needed for administrative completeness.

Figure 7. Assessment Menu

The next menu of CDSS was in the form of an assessment as presented in Figure 7 above. There were 2 criteria for self assessment: normal and asphyxia. In CDSS this followed the flow of the MTBS algorithm so that each selection of conditions according to the clinical examination result in newborn would lead to the direction of clinical action care that must be performed by health workers. The following Picture 9 showed the display of care directions based on clinical assessment results.

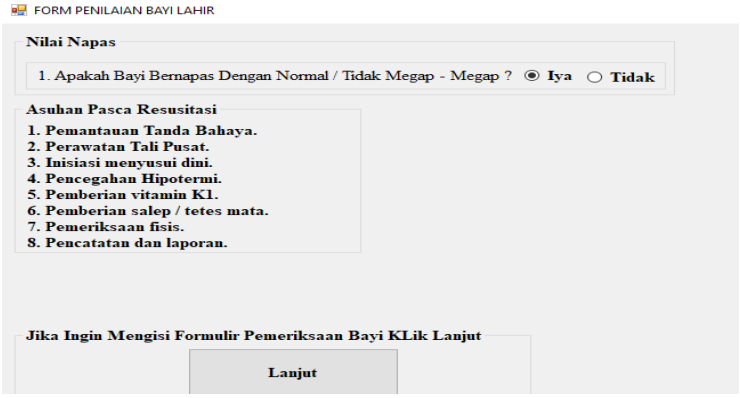

Figure 8. Display of care measure based on clinical assessment results

The CDSS neonatal management built was also equipped with a newborn data menu and consultation. The newborn data menu could produce output in the form of birth report and birth certificate, while the consultation menu produces a service report.

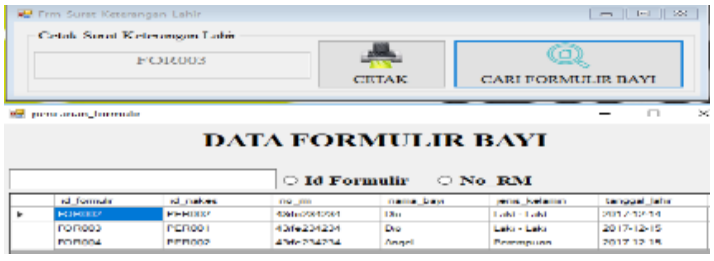

Figure 9. Display of baby form data and Print Menu of birth certificate

Baby form data and birth certificate were needed related to the need for complete data for birth information. The occurrence of kidnapping and trafficking in babies which were included in the criteria of trafficking in person was expected to be avoided by the completeness of data recording on the services of newborn babies legally. This was necessary for patient, patient family, third party or provider of financial guarantee and for their own health personnel related to reporting and manual data recording required.

5. Conclusion

Clinical decision support systems for neonatal management produced in this study were in accordance with the need of user in performing neonatal service based on the MTBS algorithm in primary care facility. The result of testing system used black-box technique had been compliant with the requirement and obtained the overall result of valid functional test. Neonatal management CDSS that had been evaluated and accepted by the user with good expectation.

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